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STREAMBANK STABILIZATION IN MICHIGAN - A SURVEY

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Cover picture.--A completely stabilized bank on the Rifle River several years after treatment. Rock riprap at the base of the bank holds the soil in place permitting vegetation to become established above. (Courtesy of Michigan Department of Conservation.)

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Streambank Stabilization in Michigan - A Survey

By

W. D. Striffler

Streambank stabilization is an essential watershed protection practice. It reduces the erosive action of streams, encourages the establishment of soil-holding vegetation, and reduces the direct production of sediment along the stream or river. Streambank stabilization is especially important along Michigan trout streams where sediment reduction improves the trout habitat and restores recreational possibilities.

In an effort to restore the productivity of trout streams, the Michigan Department of Conservation, Fish Division, has been engaged since 1950 in a program aimed at the improvement of streams as a fish habitat.

An important phase of the work is the direct and rapid stabilization of banks. Stabilization practices used are rock riprapping at the waterline, seeding and fertilizing the bank, fencing the upper bank when necessary, and occasionally tree planting. At the same time, in order to improve overall runoff relationships and reduce erosion from agricultural lands, private landowners are encouraged through the Soil Conservation Service and Agricultural Extension Service to practice good conservation and improve farming methods.

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The effectiveness of bank stabilization practices in four watersheds in northern Lower Michigan was measured in the summer of 1958 by the Lake States Forest Experiment Station and is reported here.

Review of Literature

Much work has been done throughout the country on the stabilization of steep banks of soil. Methods have been tested on road cuts, streambanks, mountain slopes, and levees along the Mississippi. Most investigators point out that a steep slope cannot be stabilized as long as soil is being removed from its base. Bates and Zeasman state:[1/]

> "It cannot be emphasized too strongly that when the foot of a fully stabilized slope is cut away, either by a rampageous stream, a stream finding a new channel, or by cutting such as is done in making roads, the entire slope above the cut is placed in an unstable condition, and will remain so until the original gradient has been reestablished or nearly so by the removal of a rectangular or wedge-shaped slice of the soil mass. This, in fact, is the key to erosion on a large scale, for practically no gullies involving large masses of soil are started except by a disturbance at, and a cutting away of the foot of a soil mass."

Many methods have been devised, both mechanical and vegetational, to protect the base of the banks and revegetate the bare soil above. Edminster, Atkinson, and McIntyre recommend some nine stabilization practices, which may be employed singly or in combinations, and which were effective in a program of streambank control on the Winooski River, Vermont.[2/] The best results were obtained from combinations of grading, rock riprap, brush matting, and planting.

1/ Bates, C. G., and O. R. Zeasman. Soil erosion, a local and national problem. Univ. Wis. Agr. Expt. Sta. Res. Bul. 99, 100 pp., illus. 1930.

2/ Edminster, Frank C., W. S. Atkinson, and A. C. McIntyre. Streambank erosion control on the Winooski River, Vermont. U.S. Dept. Agr. Cir. 837, 54 pp., illus. 1949.

Description of Study Watersheds

The results of stabilization work on four watersheds were studied. All four contain three major glacial land forms: outwash plains, till plains, and moraines. The proportions of these within each watershed determine the land use. Sandy moraines and outwash plains are largely forested, while the heavier textured till plain soils support agriculture. The Rifle, Cedar, and Tobacco watersheds, located on the eastern half of the northern Lower Peninsula have similar conditions of soils, geology, topography, and land use, while the Pine River on the western half of the State represents somewhat different conditions (table 1).

Table 1.--Characteristics of four watersheds in Lower Michigan

Item	Rifle River	Cedar River	Pine River	Tobacco River
Year treated.....	1950-51	1954	1952	untreated
Area.....acres....	100,000	70,000	160,000	177,000
Length.....miles....	45	92	191	211
Total fall.....feet.....	650	--	850	--
Av. discharge..c.f.s....	316	--	--	116
Max. discharge.c.f.s....	17,200	--	1,600	--
Land use.....percent..				
Agriculture.....	50	46	21	58
Forestry.....	50	54	79	42
Land ownership.percent..				
Private.....	70	86	77	98
Public.....	30	14	23	2

NOTE: Dashes (--) mean no measurements were taken.

Bank erosion on the Rifle, Cedar, and Tobacco Rivers appears to have been caused largely by land-use practice within the watershed. In particular, grazing and other livestock activity have caused serious disturbance along streambanks; this has been further aggravated by periodic flooding.

Severe streambank erosion in the Pine River is caused primarily by the activity of the stream while shifting its channel. In this watershed the streamline meanders down a fairly narrow flood plain, cutting deeply into the high, steep banks on either side (figs. 1 and 2).

Figure 1.--A seriously eroded high sandy bank on the Pine River. Stream action carries loose soil away from the base of the bank, keeping the bank in a continual state of instability. (Photo courtesy of Michigan Department of Conservation.)

Because of the inaccessibility of many of the banks on the Pine River, a large number were not treated; these furnish a basis for comparing treated and untreated banks within the watershed. A few untreated and a larger number of treated banks on the Cedar and Rifle Rivers also permit some within-watershed comparisons. In addition, observations were made on the Tobacco River, which was wholly untreated.

Figure 2.--A seriously eroded high clay bank on the Pine River.

Methods

Sample banks from each treated watershed were selected from Conservation Department field sheets, while those from the untreated watershed--the Tobacco River--were selected at random in the field. Only banks with a north or south aspect and a predominantly clay or sand texture were sampled. Altogether 228 banks were studied, of which 115 were treated and 113 untreated (table 2).

Table 2.--Number of treated and untreated banks sampled

Soil and aspect	Watershed				Total
	Pine	Cedar	Rifle	Tobacco	
		Treated			
Sand					
North	20	20	15	0	55
South	8	9	17	0	34
Clay					
North	1	5	5	0	11
South	5	4	6	0	15
		Untreated			
Sand					
North	9	0	1	9	19
South	18	6	1	16	41
Clay					
North	16	3	0	10	29
South	11	1	1	11	24
Total	88	48	46	44	228

Data collected to characterize each bank (in addition to aspect and soil texture class) included bank height (feet vertically) and slope in percent.

Measurements to determine the condition of the bank included (1) bank erosion, (2) waterline erosion, and (3) composition and density of the vegetative cover.

Bank erosion was determined by estimating the proportion of the bank with erosion classified as:

Serious--gullying, sand slides, undercutting, and slumps.

Moderate--rill erosion and sheet erosion through a sparse vegetative cover.

Light--light sheet erosion or other soil movement through a moderate to heavy vegetative cover.

Waterline erosion was determined by estimating the proportion of waterline classified as:

Stabilized--soil not directly subject to the washing action of the stream because of the presence of a heavy vegetative ground cover or other physical stabilizer.

Partially stabilized--soil exposed to the streamline but with a light vegetative ground cover.

Exposed--no ground cover and soil completely exposed to the streamline.

The density and composition of the ground vegetation were determined from a series of five milacre quadrats located at the waterline, at the center of the lower half of the bank, and at the center of the upper half of the bank. Where low banks (10 feet or less) were sampled, only one transect of quadrats was measured. At each quadrat the density of the vegetative ground cover and the proportion of grass, herbaceous cover, shrubs, and tree reproduction were estimated. Data were combined to give an average for each bank as a whole and for each position on the bank.

Effects of Treatment

Serious bank erosion occurred on 47 percent of the area of untreated sample banks compared with 7 percent for all treated banks (fig. 3). There was little variation between treated watersheds, with average serious erosion values ranging from 11 to 4 percent (table 3). Untreated banks showed wider variation, with the Pine River having an average of 36 percent and the Tobacco River 59 percent serious bank erosion. This may be due to the differences in land use within the watersheds.

The proportion of stabilized waterline was 28 percent for all untreated banks compared with 93 percent for treated banks. Degrees

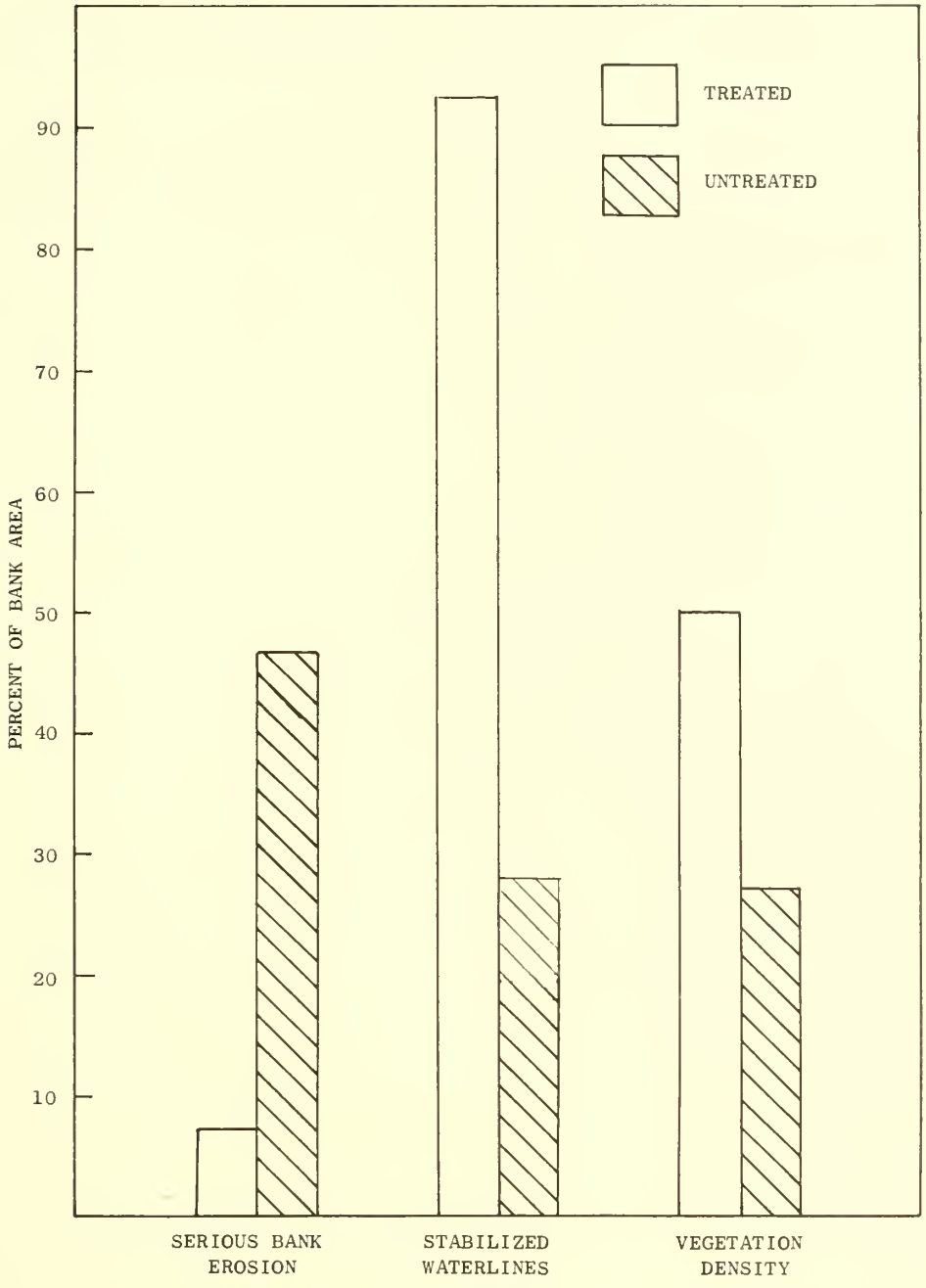

Figure 3.--Serious erosion, waterline stabilization, and vegetation density on treated and untreated banks.

Table 3.--Effects of treatment on bank erosion, waterline stabilizing, and vegetation density

(Percent of bank area)

Watershed	Serious bank erosion	Stabilized waterlines	Vegetation density
All treated banks	7.0	92.9	50.0
Pine	11.1	91.4	46.9
Cedar	7.6	91.6	48.3
Rifle	4.1	93.2	60.1
All untreated banks	47.0	27.9	25.9
Pine	36.3	35.2	35.4
Tobacco	59.8	19.3	19.9

of stabilization on treated banks varied little between watersheds, while the untreated banks of Pine and Tobacco Rivers showed 19 and 35 percent stabilization respectively.

The density of the vegetative ground cover increased as a result of treatment. The average density was 50 percent for all treated banks and 26 percent for untreated banks. Vegetative density was inversely related to the degree of serious bank erosion (fig. 4).

The composition of the vegetative ground cover as well as its density varied between treated and untreated banks. The most significant change was a more even distribution of tree and brush reproduction over the treated banks. Of the total vegetation on the upper portion of all untreated banks, 30 percent was tree reproduction and woody shrubs. This decreased to 15 percent in the center of the bank and 10 percent at the waterline. For treated banks, trees and woody shrubs made up 28 percent of the vegetation and were uniformly distributed over the bank. This also illustrates the tendency for a more permanent vegetative type to become established once the waterline has been stabilized.

The banks examined during this survey usually had a greater proportion of volunteer species than species planted during the treatment. This indicates that planted vegetation serves only as a temporary ground cover until native species can become established. Planted species observed were largely Reed canarygrass (Phalaris arundinacea) and purpleosier willow (Salix purpurea). Mill chaff, also used occasionally, resulted in a profusion of wild grasses and herbaceous

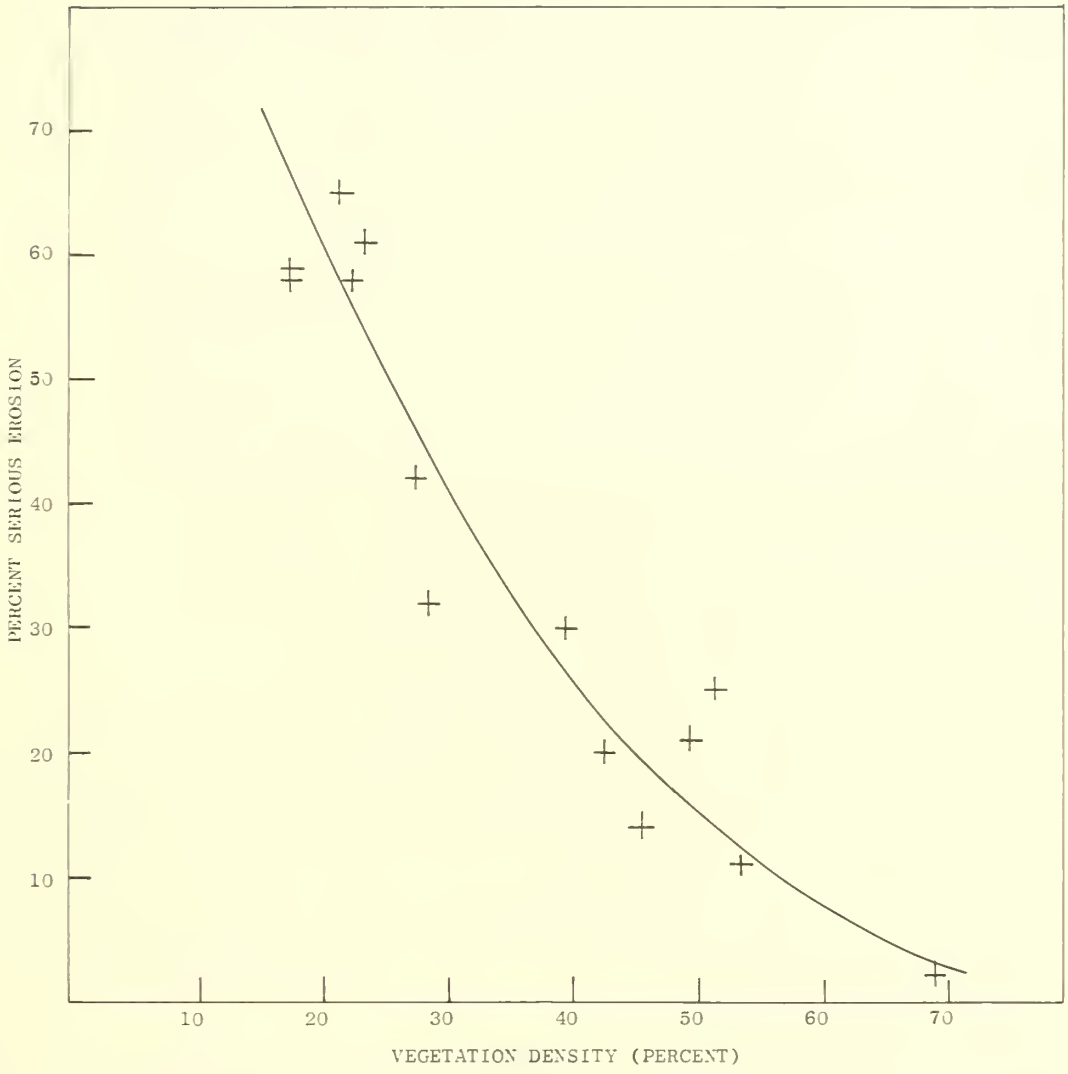

Figure 4.--Relation of vegetation density to serious erosion (free-hand curve).

weeds. Major volunteer species included native willows (Salix spp.), balsam poplar (Populus balsamifera), bigtooth aspen (P. grandidentata), quaking aspen (P. tremuloides), staghorn sumac (Rhus typhina), and alder (Alnus spp.).

Influence of Bank Characteristics on Stability

Of the bank characteristics studied (slope, aspect, soil texture, and bank height), only soil texture had any consistent influence on bank stability (table 4).

Table 4.--Influence of soil texture on erosion, stabilization, and vegetation density of streambanks

Soil texture	Percent of bank area with--		
	Serious erosion	Stabilized waterline	Vegetative cover
Treated banks			
Sand	5	93	54
Clay	15	95	40
Untreated banks			
Sand	42	35	30
Clay	52	22	24

Untreated clay banks tended to have more serious erosion, less waterline stabilization, and lower densities of ground vegetation than untreated sand banks. These relations also held true for treated banks with the exception of waterline stabilization, where, as would be expected, the texture of the soil had no effect upon the stabilizing influence of rock riprap (fig. 5 and cover picture).

The composition of the vegetative cover also varied with soil texture. A greater proportion of trees and shrubs occurred on clay banks than on sand banks. This was true of both treated and untreated banks (table 5).

Several other influences observed during the survey strongly affected the stability of the streambanks. These included grazing and recreational use.

Figure 5.--A well-stabilized sandbank on the Pine River 6 years after treatment.

Table 5.--Composition of the vegetative cover

Soil texture	Percent of bank area with--	
	Trees and shrubs	Grass and herbs
Treated banks		
Sand	25	75
Clay	33	67
Untreated banks		
Sand	17	83
Clay	22	78

Grazing and trampling by cattle often caused serious erosion on both treated and untreated banks. Cattle damage was most severe on low banks where stock crossed or grazed along the waterline. Where bank treatment included fencing, recovery was generally excellent. However, cattle crossings in these areas often became very badly eroded because of the concentration of livestock at these points. Properly graded and graveled crossings were considerably better (fig. 6).

Occasionally recreational use of banks resulted in failure of upper bank stabilization. Access trails up and down and across the banks caused occasional gullying and, in high sandbanks, caused serious slides and soil slippage (fig. 7). In at least one instance, sand slides completely obscured rock riprap at the base of the bank.

Figure 6.--A well-controlled cattle crossing. Access trails have been graded and graveled permitting cattle to cross without disturbing the stability of the soil and the stream bottom.

Figure 7.--Recreational use of this treated bank has caused sand slides and gullies to form along access trails.

Significance of Results

The results of this survey show that the bank stabilization methods employed (rock riprap, seeding, and fertilization) were highly effective. Bank erosion was reduced nearly 40 percent, waterlines were stabilized, and upper banks were revegetated to some degree. These processes could be expected to occur in watersheds similar to those surveyed.

Stabilization of the waterline by rock riprap or other mechanical means appears to be the key to successful bank stabilization. Once the foot of the bank is stabilized, the stream can no longer carry away soil from the base, undercutting is stopped, and eventually the bank reaches a state of equilibrium where slumps and slides no longer occur. As soil movement ceases, vegetation becomes established and helps to hold the soil.

The revegetation period of the entire bank is probably shortened considerably by seeding and fertilizing the bank.

The texture of the streambank soil is an important consideration. Although both sand and clay banks respond to treatment to about the same degree, a greater amount of serious erosion still occurs on the clay banks. The testing of species and planting methods might improve this phase of stabilization.

Summary

A survey of streambank stabilization in northern Lower Michigan was made during the summer of 1958. Data were collected and analyzed from 113 untreated and 115 treated banks on 3 treated watersheds and 1 untreated one with the following results:

1. Bank stabilization is highly effective in stabilizing waterlines, reducing bank erosion, and increasing the density of the vegetative cover. Serious erosion on treated banks averaged 7 percent compared with 47 percent on untreated banks. Waterlines of treated banks were 93 percent stabilized compared with 28 percent on untreated banks. The density of the vegetative cover on treated banks averaged 50 percent compared with 26 percent on untreated banks.

2. Of the physical bank features examined, only the texture of the soil bore any consistent relationship to the stability of the bank. Clay banks generally had more serious erosion, less stabilized waterlines, and less ground vegetation. Sand and clay banks both responded to treatment to the same degree.

3. Once the banks were well stabilized by planting, volunteer vegetation usually took over from planted vegetation.

4. The success of stabilization was adversely affected by cattle grazing or trampling or the recreational use of the bank. Fencing the bank to keep out cattle is of utmost importance.

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